Food of Fish Collected on Artificial Reefs in the New York Bight and Off Charleston, South Carolina

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Introduction

Artificial reefs have been used for centuries to enhance or concentrate populations of aquatic organisms. The principle behind their use is that of providing or increasing one or more environmental factors, e.g., cover, food, or spawning grounds, which limit the potential development of these populations. In recent years U.S. use of artificial reefs has been mostly in recreational fishery management and has increased somewhat proportionately with the increase in fishing pressure and the decrease in coastal and estuarine environmental quality. With rising fuel costs, attempts to enhance fishing near to ports will surely include the construction of more artificial reefs.

Despite their use for several decades in the United States (Steimle and Stone, 1973), major questions about the dependency of fish on artificial reefs persist. With the probable increase in artificial reef construction, some clearer insights into the function of artificial reefs must be gained, to make intelligent and optimum use of this management tool. A question that has not received enough attention concerns the role of artificial reefs in increasing or improving the quality or quantity of forage for fish. Besides the obvious cover provided by artificial reefs, the hard surfaces of reef material are colonized by an encrusting community. If the fish inhabiting artificial reefs depend heavily on this community for food, this would further define the function of the reef in attracting and maintaining fish populations and would assist artificial reef designers to develop more effective and productive structures.

This study was conducted to address the question of whether artificial reefs are, or can be, important providers of forage for fish. The study was part of a more extensive investigation by the former Bureau of Sport Fisheries (now National Marine Fisheries Service, NOAA) on the construction, utilization, and effectiveness of artificial reefs (Parker et al., 1974; Stone et al., 1974).

Methods

The 309 stomachs from 11 species of fish (Table 1) used in this study were

Table 1.—Summary of fish samples obtained for this study (names of fishes from AFS, 1970.)

Species		Number of samples obtained at:		
Common name	Scientific name	Atlantic Beach, N.Y.	Monmouth Beach, N.J.	Charleston, S.C.
Atlantic cod	*Gadus morhua*	32		
Red hake	*Urophycis chuss*	15	16	
Rock sea bass	*Centropristis philadelphica*			8
Black sea bass	*Centropristis striata*		7	52
Sheepshead	*Archisargus probatocephalus*			3
Pinfish	*Lagodon rhomboides*			3
Scup	*Stenotomus chrysops*			3
Northern kingfish	*Menticirrhus saxatilis*	23		
Tautog	*Tautoga onitis*	43	14	
Cunner	*Tautogolabrus adspersus*	39	48	
Winter flounder	*Pseudopleuronectes americanus*		3	

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ABSTRACT—The construction of artificial reefs is a popular means of countering increasing recreational fishing pressure. Despite their popularity, many questions persist about their function and effectiveness as a management tool. This paper discusses the role of the epifauna, which develops on artificial reefs and most other submerged hard surfaces, in providing food for the fish population found on or near artificial reefs. The stomach contents of 309 specimens of 13 species of fish, collected by spear or hook and line at three artificial reef sites, were examined to better define their trophic dependence on reef epifauna. Although most examined species did not appear to be highly dependent on the reef epifauna for food, there is a need for further study.

Table 2.—Locations and characteristics of the three artificial reefs where fish were collected.

Reef site	Location	Date established	Depth (m)	Characteristics
Charleston	13 km east of Keawah Island, S.C.	October 1967	15	70 car bodies placed on a sandy bottom.
Monmouth Beach	3.25 km east of Monmouth Beach, N.J.	August 1966	15-18	16 car bodies, 20 pyramidal 12-tire units, and 1,100 single tire units on a sandy bottom. Rounded outcroppings of rock with patches of sand, shell, and cobbles were nearby.
Atlantic Beach	5.5 km south of Atlantic Beach, N.Y.	July 1967	20	404 car bodies, one metal and one wooden barge placed on a sandy bottom.

Table 3.—Food of fish collected on the Charleston, S.C., artificial reef, presented as percent of total volume of stomach (S) and intestine (I) contents.

	Predator									
	Black sea bass		Rock sea bass		Scup		Pinfish		Sheepshead	
Prey	S	I	S	I	S	I	S	I	S	I
Chaetognatha					50.0					
Mollusca (unidentified)	<1.0									
Solen sp.	6.1	3.9	2.9	4.1				16.7		
Polychaeta	<1.0	5.4								
Crustacea										
Cirripedia	5.0	10.1							20.5	27.5
Cumacea	<1.0	<1.0				93.3	33.3	20.8		
Isopoda	<1.0	<1.0								
Amphipoda	10.9	16.4		2.7			66.7	62.5	4.0	8.6
Decapoda (unidentified)	3.4	7.2		42.5						
Brachyura (unidentified)	12.4	13.5	7.7	13.7	50.0					
Cancridae	<1.0	2.5	2.9							
Portunidae	37.4	5.2	36.5	5.5						
Xanthidae	<1.0	2.3	24.0	5.5						
Tunicata	<1.0	1.2							67.6	21.4
Pisces	11.7		26.0							
Unidentified organic matter	4.9	38.6		26.0		6.7			6.8	42.0
Number of predators examined	52		8		3		3		3	
Number of empty guts (S + I)	2		0		1		0		0	
Mean predator fork length (cm)	13.7		15.6		8.9		10.2		29.5	

collected at three artificial reef sites: Off Charleston, S.C.; Monmouth Beach, N.J., and Atlantic Beach, N.Y. The characteristics of each site are presented in Table 2. Fish samples were collected by diver-held spear at the Charleston and Monmouth Beach sites, and by hook and line at the Atlantic Beach site. These two methods were used to overcome the difficulty in obtaining samples of reef fish by more standard methods (i.e., trawling and bottom longlines) because of the problem of hanging up. Hand spearing also allows the collector to observe whether any food material is regurgitated. Regurgitation, because of rough handling (i.e., within the cod end of a trawl), could be a very important source of error as well as in the use of baited hooks on longlines in food habits studies. The disadvantage of the chosen sampling methods is that they produce small quantities of samples per unit effort than other methods, thus the relatively small number of samples examined in this study. Collections were made primarily between late spring and early fall (except for several winter collections at the Atlantic Beach site) from 1967 through 1970. The species and number of individuals per species were determined by what was actually caught by hook and line or speared by the divers, who tried to select their targets at random and to be representative of dominant species present. Stomachs and intestines were quickly removed from all fish samples and preserved in 10 percent buffered formalin. In the laboratory, the total volume of the contents as well as the volume of each identifiable food item were determined for the contents of the gut (stomach and intestine) of each fish.

Results and Discussion

The results of the gut content analysis of the five most commonly sampled species for each study site are presented in Tables 3-5. These results provide little concrete evidence to support the hypothesis that most fish species found in, on, or adjacent to temperate artificial reefs are present because of a high dependence on the reef-associated fauna or flora for food. Faunal groups or species that are, without a doubt, closely associated with reefs, e.g., hydroids, mussels

Table 4.—Food of fish collected on the Monmouth Beach, N.J., artificial reef, presented as percent of total volume of stomach (S) and intestine (I) contents.

	Predator									
	Red hake		Black sea bass		Tautog		Cunner		Winter flounder	
Prey	S	I	S	I	S	I	S	I	S	I
Hydrozoa	<1.0				7.3	2.2	8.0	1.4		
Bryozoa						2.7				
Mollusca (unidentified)		4.3					<1.0			
Mytilus edulis					9.1	35.1	31.5	49.5		
Cephalopoda			7.7							
Polychaeta (unidentified)					4.7		9.6	<1.0	16.7	2.7
Nereis sp.	2.9	2.4							83.3	8.1
Crustacea										
Cirripedia								<1.0		
Copepoda							1.0	2.8		
Cumacea							1.3	<1.0		
Amphipoda	<1.0	<1.0					2.0	1.0		
Mysidacea							<1.0	1.4		
Decapoda (unidentified)		22.7	61.5				<1.0	8.8		
Caridea (unidentified)	<1.0	5.3					1.0	6.5		
Crangon septemspinosus	11.1						2.6	3.7		
Brachyura (unidentified)	2.6	16.3			3.6		18.2	3.2		
Cancer spp.	32.7	1.1	30.8	11.1	27.5	54.1	6.6			
Echinodermata										
Echinarachnius parma					37.8			3.2		
Tunicata	44.3	1.1								
Pisces	3.5						4.0	1.9		
Unidentified organic matter	1.6	47.1		88.9	10.0	5.9	12.3	14.8		89.2
Number of predators examined	16		7		14		48		3	
Number of empty guts (S + I)	2		3		0		11		0	
Mean predator fork length (cm)	33.1		21.9		23.0		15.8		23.1	

(*Mytilus*), barnacles (cirripedia), and possibly tunicates, occurred in the guts of most species examined but only exceeded 25 percent of total stomach or intestine volume in three species: Tautog, cunner, and sheepshead. Barnacles comprised 37 percent of the total intestinal volume of Atlantic Beach tautog, while *Mytilus* comprised 35 percent of the intestinal volume of Monmouth Beach tautog. *Mytilus* also comprised over 40 percent of cunner intestinal volume at both Atlantic Beach and Monmouth Beach sites. However, tautog stomach contents, reflecting more recent feeding, indicate that *Cancer* crabs and sand dollars, *Echinarachnius parma,* were as or more commonly selected. Also, the stomachs of cunner contained both *Mytilus* and *Crangon septemspinosus,* the sand shrimp (a sandy sediment inhabitant), as major constituents. The separation of stomach and intestine in the cunner may be a moot question as Chao (1973) points out. The few sheepshead examined at the Charleston site showed the highest reef dependence, assuming the tunicates were the encrusting type, with most (88 percent) of the stomach and half (49 percent) of the intestinal volume comprised of barnacles and tunicates.

Full identification of most of the items found in the fish guts was impossible or impractical (tediously comparing microscopic fragments to a type set of many possible items). Thus, there is a good chance that some of the other material found in the guts could have been other species also closely associated with the reef's encrusting or epifaunal invertebrate community, e.g., the Xanthid crabs in the diets of rock sea bass at the Charleston site or the amphipods preyed upon by northern kingfish at the Atlantic Beach site. This could possibly increase our assessment of reef dependence, but we can only speculate at this point.

On the other hand, the large amount of identifiable material most probably consumed on the adjacent, nonreef sediments made apparent the opportunistic nature of most fish collected in the study. These nonreef food items, including chaetognaths, the razor clam (*Solen*), cumacea, portunid crabs, nerid polychaetes, *Crangon* shrimp, and sand dollars, *E. parma,* comprised major portions of the diets of most of the fish examined. Other important diet items, e.g., *Cancer* crabs and fish, could have potentially been preyed upon on or off the reef habitat and thus cannot provide any insight into the forage function of artificial reefs.

Other studies which have examined the food habits of the species in our study indicate similar results. For example, Chao (1973) and Shumway and Stickney (1975) indicated that barnacles (*Balanus*) and *Mytilus* were generally the dominant prey of cunner in southern New England waters. Olla et al. (1975) report *Mytilus* to be the most frequently occurring food in the digestive tract of

Table 5.—Food of fish collected on the Atlantic Beach, N.Y., artificial reef, presented as percent of total volume of stomach (S) and intestine (I) contents.

	Predator									
	Atlantic cod		Red hake		Northern kingfish		Tautog		Cunner	
Prey	S	I	S	I	S	I	S	I	S	I
Hydrozoa							<1.0		5.7	3.3
Gastropoda	2.3									
Bivalvia (unidentified)	1.0						<1.0	2.1	2.5	
Mytilus edulis		<1.0					3.4		16.5	42.9
Solen sp.									2.9	
Polychaeta (unidentified)		6.7	<1.0		17.1	11.6	<1.0			
Nereis sp.	3.9	<1.0			46.5	11.5				
Flabelligeridae	<1.0		1.5				<1.0			
Polynoidae					1.2					
Glyceridae					2.4	4.3				
Crustacea										
Cirripedia							<1.0	37.2		
Amphipoda		<1.0			15.3	23.2	<1.0		<1.0	
Mysidacea									2.5	1.1
Decapoda (unidentified)			<1.0	4.1			<1.0			
Homarus americanus	1.3									
Caridae (unidentified)	<1.0	2.0	<1.0	3.3						
Crangon septemspinosus	5.7	<1.0	93.3	30.8	2.7				39.0	37.4
Pandalus sp.									<1.0	2.2
Anomura	1.9									
Brachyura	<1.0	24.4		4.3			6.7	23.4	24.1	4.4
Cancer sp.	55.8	8.0	2.7		7.3		78.2		<1.0	4.4
Pisces	27.7	<1.0	<1.0						1.6	
Unidentified organic matter		56.4	1.0	57.5	7.3	49.3	8.6	37.2	3.2	4.4
Number of predators examined	32		15		23		43		39	
Number of empty guts (S + I)	2		1		0		11		5	
Mean predator fork length (cm)	59.5		35.6		25.1		29.1		19.3	

tautog in their Long Island, N.Y., study. Bigelow and Schroeder (1953) and Kendall (1977) reported that black sea bass were opportunistic benthic omnivores, with the adults subsisting chiefly on decapod crustacea, fish, and some mollusks. The classification "opportunistic benthic omnivore" also generally fits the remaining species in this study and agrees with other food habit reports in the literature, e.g., Bigelow and Schroeder (1953).

In conclusion, this study suggests that few fish species found around Atlantic temperate artificial reefs during the study period are obligated for sustenance to the encrusting or attached epifaunal forage species that develop on the hard surfaces of artificial reef habitats. Other artificial reef studies in temperate or warmer waters (Randall, 1961; Russell, 1975) also suggest that, generally, reef-dependent food resources may be less important in attracting and accommodating fish populations than shelter or other behavioral requirements provided by the reef structure. Olla et al. (1975) indicate that even for the tautog, which preys primarily on mussels commonly found attached to hard surfaces such as artificial reefs, the necessity for shelter may be the limiting factor in its population size.

The results of this study are far from conclusive. Additional studies should be designed that would also examine factors such as the quantity of forage available on artificial reefs compared to that of the adjacent bottom, or the food habits of juvenile fishes collected on reefs. This type of information is essential in designing and planning effective artificial reefs and making them a more useful fishery management tool.

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